AD-A096 164 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 20/4
H6123 - CONJUGATE DEPTH IN EITHER A TRAPEZODIAL, TRIANGULAR, OR--ETC(U)
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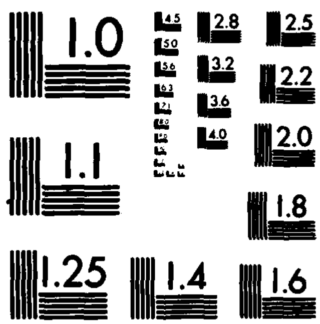

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM H6123 - Conjugate Depth in Either a Trapezodial, Triangular, or Rectangular Open Channel

PROGRAM Number 722-F3-R0-6AI

PREPARING AGENCY Hydraulic Analysis Division, Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, MS, 39180

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM — PHASE	STAGE
(10) Martin T. Hebler	Nov 1973 Documented June 78 (11)	Origin	Operational

The purpose of this is to

A. PURPOSE OF PROGRAM

To compute the conjugate depth at a hydraulic jump in either a trapezoidal, triangular, or rectangular open channel.

References: (1) Chow, Ven Te, Open Channel Hydraulics, McGraw-Hill, 1959 pp 53-56
(2) Schied, Francis, Numerical Analysis, Schaum's Outline Series, McGraw-Hill, 1968, pp 315-317.

(12) (16)

B. PROGRAM SPECIFICATIONS

SEE FOLLOWING PAGE

LEVEL II

C. METHODS

The program is written in G635 time-share series, FORTRAN IV, and is part of a Conversationally Oriented Real-Time Program-Generating System (CORPS). The program consists of a main program and three subroutines. The main program handles all I/O requirements with the subroutines handling the computation.

D. EQUIPMENT DETAILS

The program was developed and is operational on the WES G635, Vicksburg, MS. It is also operational on HIS 66/80, Macon, GA, and Boeing CDC, Seattle, WA.

E. INPUT-OUTPUT

The required inputs which are entered at execute time are: discharge, cfs, bottom width, ft, (0 if tria sect.), side slope (0 if rect sect), number of flow depths and the flow depths, ft. Output includes the type of cross section and the given data, plus the conjugate depth, ft.

F. ADDITIONAL REMARKS

Complete documentation of this program is available from the Engineer Computer Programs Library, Technical Information Center, WES.

B. PROGRAM SPECIFICATIONS:

Language: ANSI FORTRAN (FORTRAN IV)

Solution Requirements: The run command

RUN WESLIB/CORPS/H6123, R

and the inputs defined in (E).

Method of Analysis: Solves the momentum equation for the conjugate depth by application of Newton's Tangent Method.

Core Requirements G635: 11 K words

External Storage: None

Restrictions: Velocity distribution is uniform across the flow section and the invert slope is small (i.e., < 10 degrees).

General Equation:

$$A_1\bar{y}_1 + \frac{Q^2}{gA_1} = A_2\bar{y}_2 + \frac{Q^2}{gA_2}$$

where Q is discharge (cfs), g is acceleration of gravity (32.2 ft/sec^2), A_1 and A_2 are the respective cross-section areas (ft^2) for flow depth and conjugate depth, and $\bar{y}_1$ and $\bar{y}_2$ are the distances (ft) of the centroids of the respective areas A_1 and A_2 below the water surface.

Range of Quantities: Unlimited for practical application

Accuracy: Governed by accuracy of input data; conjugate depth computed to ± 0.001 ft.

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering Computer Program Library Standards and Documentation, Appendix B

PART I: ENGINEERING DESCRIPTION

1. PROGRAM NUMBER: 722-F3-R0-6AI

2. TITLE: H6123 - Conjugate Depth in Either a Trapezoidal, Triangular, or Rectangular Open Channel.

3. REVISION LOG: N/A

4. PURPOSE OF PROGRAM: To compute the conjugate depth at a hydraulic jump in either a trapezoidal, triangular, or rectangular open channel.

References:

a. Chow, Ven Te, Open Channel Hydraulics, McGraw-Hill, 1959, pp 53-56.

b. Schied, Francis, Numerical Analysis, Schaum's Outline Series, McGraw-Hill, 1968, pp 315-317.

5. STEP SOLUTION:

a. Enter inputs:

(1) Discharge (Q), cfs

(2) Channel bottom width (b), ft (0 if triangular section)

(3) Channel side slope (z), expressed as the cotangent (0 if rectangular section)

(4) Flow depth (y_1), ft

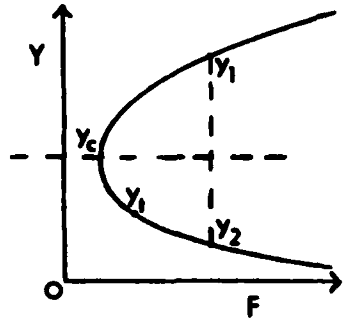
b. Computational steps:

(1) Critical depth (y_c) using subroutine H6140

(2) Specific force (F_1) at y_1 using subroutine H6124

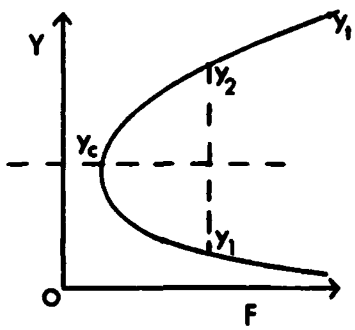
(3) Determine trial conjugate depth (y_t)

If $y_c < y_1$, then $y_t = \frac{y_c}{2}$



SPECIFIC FORCE CURVE

If $y_c = y_1$, then the conjugate depth (y_2) is equal to y_c ; y_2 is returned to the main program. If $y_c > y_1$, then $y_t = \frac{y_c^2}{y_1}$



SPECIFIC FORCE CURVE

(4) Specific force (F_t) and area (A_t) at y_t using subroutine H6124

(5) Define function $F(y_t)$ to be used for Newton's Tangent Method

$$F(y_t) = F_t - F_1$$

(6) First derivative of $F(y_t)$ with respect to y_t

$$\frac{d}{dy_t} F(y_t) = A_t - \frac{Q^2(b + 2zy_t)}{gA_t^2}$$

(7) Conjugate depth (y_2) is calculated using Newton's Tangent Method

(8) If $y_2 \leq 0.0$, then $y_t = \frac{y_c}{2^m}$, where $m = 2,3,\ldots$, depending on the number of times the condition $y_2 \leq 0.0$ occurs. Transfer is to step (4) and the process is repeated until $y_2 > 0.0$. Step (9) is then entered.

(9) If $|y_2 - y_t| \geq .001$, then $y_t = y_2$ and the procedure returns to step (4) and is repeated until $|y_2 - y_t| < .001$. The value of y_2 is returned to the main program.

c. The given data, plus the conjugate depth, are printed.

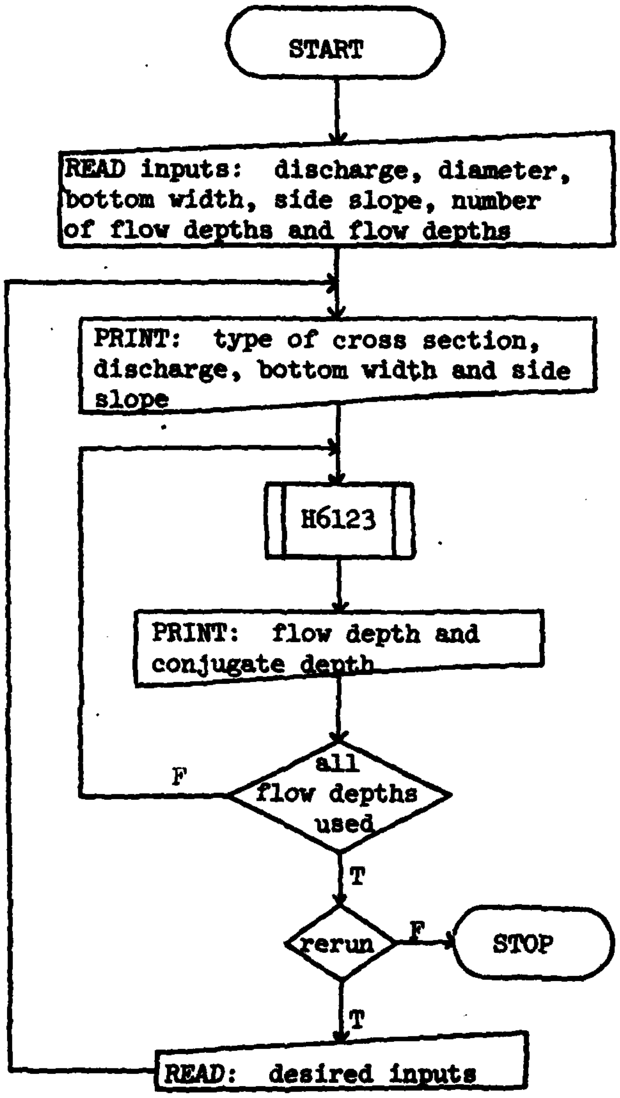
6. <u>ACCURACY</u>: Governed by accuracy of input data; conjugate depth is computed to $\pm$ .001 ft.

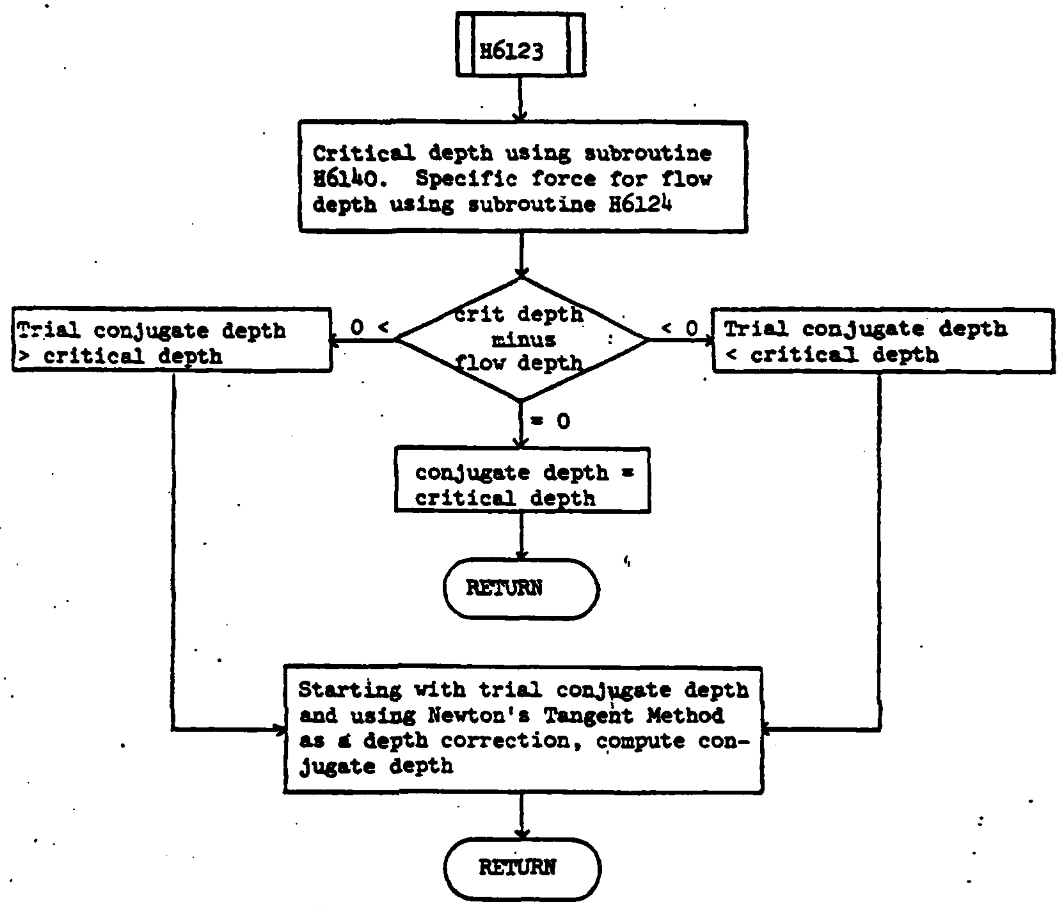
7. <u>REMARKS</u>: Velocity distribution is uniform across flow section and the invert slope is small (i.e., < 10 degrees).

PART II: COMPUTER FUNCTIONAL DESCRIPTION

1. **REVISION LOG**: N/A

2. **FUNCTIONAL FLOW CHART**:




H6123
Critical depth using subroutine H6140. Specific force for flow depth using subroutine H6124
crit depth minus flow depth
0 <
< 0
= 0
Trial conjugate depth > critical depth
Trial conjugate depth < critical depth
conjugate depth = critical depth
RETURN
Starting with trial conjugate depth and using Newton's Tangent Method as a depth correction, compute conjugate depth
RETURN

3. EQUIPMENT AND OPERATING SYSTEM: The program was developed on a G635 time-share system in which input/output equipment consisted of a Model 33 remote teletype. It is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

4. INPUT REQUIREMENTS: The required inputs are entered via the user's time-share terminal device in free field format. All input cues and reads are performed in the main program. The subroutines handle the computations. Since computations are done in the subroutines, and subroutines H6140 and H6124 are subordinate to H6123, the necessary inputs to subroutine H6123 are passed via the CALL statement. The calling sequence is:

$$\text{CALL H6123}\ (arg_1,\ldots,arg_5)$$

where:

arg_1 - discharge, cfs

arg_2 - bottom width, ft

arg_3 - side slope (cotangent)

arg_4 - flow depth, ft

arg_5 - conjugate depth, ft

All arguments are floating point. Arguments 1-4 are the inputs and argument 5 is the output.

5. SECONDARY STORAGE INPUT: None

6. INPUT DATA DESCRIPTION: The following names are used for the input variables in program H6123.

DISCH - discharge, cfs (arg_1)

BWID - bottom width, ft (arg_2)

SSLOPE - side slope (cotangent) (arg_3)

N - number of flow depths, integer

Y - flow depth, ft (arg_4)

7. OUTPUT DATA DESCRIPTION: The following name is used for the output variable in program H6123

DEPTH2 - conjugate depth, ft (arg_5)

8. PROGRAM ERROR MESSAGES: None

9. VARIABLE DEFINITIONS:

AREA - area at trial conjugate depth, ft^2

BWID - bottom width, ft (0 if tria sect)

CRIT - critical depth, ft; returned from subroutine H6140

N - number of flow depths, $0 < N \leq 25$

Y - flow depth, ft; dimensioned max 25

DEPTH1 - flow depth, ft; equal to Y(I) for I = 1,...,N

DEPTH2 - conjugate depth, ft

DEPTHT - trial conjugate depth, ft

DISCH - discharge, cfs

F - function of trial conjugate depth used for Newton's Tangent Method, ft^3; the value of the function is a specific force difference between that at trial conjugate depth and flow depth

FP - first derivative of function (F) with respect to trial conjugate depth, ft^2

FORCE - specific force, ft^3; returned from subroutine H6124

F1 - working storage to hold FORCE at a constant when FORCE is returned from H6124 as the specific force at flow depth, ft^3

G - acceleration of gravity, 32.2 ft/sec^2

HFILE - five character name of program; passed to WESLIB count routine HACCT

LQZ - equal 1, execute all input cues and reads; equal 2, call WESLIB routine RERUN and enter only desired inputs

LQX - equal 1, print instructions from RERUN; equal 3, no print

JKL - direct return from RERUN to desired input read

KKK - total number of inputs; passed to RERUN

M - power of 2 to converge Newton's Tangent Method if conjugate depth ≤ 0

TYPE - character; type of flow cross section; trap, tria, or rect

ZZZZZ - character; equal RE, rerun; equal ST, stop

10. EXAMPLE CASE: Compute the conjugate depth for 6 given flow depths in a rectangular channel.

a. Input data:

Discharge (DISCH) = 100.00 cfs

Bottom width (BWID); (0 if tria sect) = 3.51 ft

Side slope, cotangent (SSLOPE); (0 if rect sect) = 0.0

Number of flow depths (N) = 6

Flow depths (Y(I), for I = 1, N) = 1.00, 1.43, 2.50, 4.00, 5.27, and 6.00 ft

b. Output:

```
INPUT  H6123-CONJUGATE DEPTH-TRAP,RECT,TRIA-OPEN CHANNEL

AA-ENTER DISCHARGE,CFS.
=100
AB-ENTER CHAN BOTTOM WIDTH,FT (0 IF TRIA SECT).
=3.51
AC-ENTER CHAN SIDE SLOPE, (0 IF RECT SECT).
=0
AD-ENTER THE NUMBER OF DEPTH(S) FOR WIHICH THE CONJUGATE DEPTH IS TO BE
CALCULATED. MUST NOT EXCEED 25 DEPTHS.
=6
AE-ENTER THE  6 DEPTH(S) SEPARATED BY COMMAS.
=1,1.43,2.5,4,5.27,6.5

OUTPUT  H6123-CONJUGATE DEPTH(S) FOR A RECT OPEN CHANNEL

DISCHARGE =        100.00 CFS
BOTTOM WIDTH =       3.51 FT
SIDE SLOPE =         0.   H:1V

   FLOW     CONJUGATE
   DEPTH      DEPTH
   (FT)       (FT)
   1.00       6.62
   1.43       5.27
   2.50       3.41
   4.00       2.07
   5.27       1.43
   6.50       1.03

ENTER RERUN OR STOP
=STOP
```

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering and Computer Program Library Standards and Documentation, Appendix C

PART III: FILE DOCUMENTATION

1. REVISION LOG: N/A

2. TITLE: H6123 - Conjugate Depth in Either a Trapezoidal, Triangular, or Rectangular Open Channel.

3. PROGRAM SOURCE LISTINGS: See pages 12-14

4. NUMERICAL AND LOGICAL ANALYSIS: Solves the momentum equation for the conjugate depth by application of Newton's Tangent Method.

5. SUBROUTINES NOT DOCUMENTED IN ABSTRACT: The following subroutines are used in program H6123.

   a. SUBROUTINE H6124(DISCH, BWID, SSLOPE, DEPTH, AREA, FORCE)
   The subroutine statement for H6124 as documented in program H6124 is:

   SUBROUTINE H6124(DISCH, BWID, SSLOPE, DEPTH, ENERGY, FORCE)

   The argument list was changed to (a) to facilitate the solution of program H6123. This change has no effect on H6124 as documented.

   b. SUBROUTINE H6140(DISCH, WIDTH, SSLOPE, DEPTH, CRIVEL)

   Complete documentation of these subroutines is available from the Engineer Computer Program Library, Technical Information Center, WES.

6. MISCELLANEOUS: The program is part of the CORPS computer system. CORPS is an acronym standing for Conversationally Oriented Real-Time Program-Generating System. The program is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

The source listing on page 12 contains the first line run command and brief for H6123. This first line run command runs the binary H6123B of the source listing on pages 13-14 (Fortran source of H6123) and attaches the WESLIB routines HACCT and RERUN.

```
0001*#RUN WESLIB/CORPS/H6123B,R;WESLIB/RERUN,R;WESLIB/HACCT,R
0800 63THIS PROGRAM COMPUTES CONJUGATE DEPTHS IN EITHER A TRAPEZOIDAL,
0810 62TRIANGULAR, OR RECTANGULAR CHANNEL.  INPUTS REQUIRED ARE CHAN-
0820 59NEL BOTTOM WIDTH IN FT(ZERO IF TRIANGULAR SECTION), CHANNEL
0830 61SIDE SLOPE EXPRESSED AS THE COTANGENT OF THE ACUTE ANGLE WITH
0840 63RESPECT TO THE HORIZONTAL(ZERO IF RECTANGULAR SECTION), AND THE
0850 61FLOW DEPTH(S) IN FT.  OUTPUT INCLUDES THE GIVEN DATA, TYPE OF
0860 42CROSS-SECTION, AND THE CONJUGATE DEPTH(S).
0999*06FINISH
```

```
*#RUN *=;/CORPS/H6123B(NOGO)
CHARACTER TYPE*4,HFILE*5
DIMENSION DEPTH(25)
HFILE=5HH6123
LQZ=1;LQX=1
15000 CALL HACCT(HFILE)
PRINT 15111
15111 FORMAT(/"INPUT  H6123-CONJUGATE DEPTH-TRAP,RECT,TRIA-OPEN
& CHANNEL"//)
GO TO(15003,15023),LQZ
15003 PRINT 15004
15004 FORMAT("AA-ENTER DISCHARGE,CFS.")
15005 READ,DISCH
GO TO(15007,15023),LQZ
15007 PRINT 15008
15008 FORMAT("AB-ENTER CHAN BOTTOM WIDTH,FT (0 IF TRIA SECT).")
15009 READ,BWID
GO TO(15011,15023),LQZ
15011 PRINT 15012
15012 FORMAT("AC-ENTER CHAN SIDE SLOPE, (0 IF RECT SECT).")
15013 READ,SSLOPE
GO TO(15015,15023),LQZ
15015 PRINT 15016
15016 FORMAT("AD-ENTER THE NUMBER OF DEPTH(S) FOR WIHICH THE CONJUG
&ATE DEPTH IS TO BE"/"CALCULATED. MUST NOT EXCEED 25 DEPTHS.")
15017 READ,N
GO TO(15019,15023),LQZ
15019 PRINT 15020,N
15020 FORMAT("AE-ENTER THE ",I2," DEPTH(S) SEPARATED BY COMMAS.")
15021 READ,(DEPTH(I),I=1,N)
GO TO(15026,15023),LQZ
15023 KKK=5
CALL RERUN(KKK,LQX,JKL)
GO TO(15005,15009,15013,15017,15021,15026),JKL
15026 TYPE=4HTRAP
IF(BWID) 15029,15028,15029
15028 TYPE=4HTRIA
15029 IF(SSLOPE) 15031,15030,15031
15030 TYPE=4HRECT
15031 PRINT 15032,TYPE,DISCH,BWID,SSLOPE
15032 FORMAT(/"OUTPUT  H6123-CONJUGATE DEPTH(S) FOR A ",A4," OPEN
& CHANNEL"//"DISCHARGE = ",F12.2," CFS"/"BOTTOM WIDTH = ",F9.2," FT
&"/"SIDE SLOPE = ",F11.2,"H:1V"//4X,"FLOW",5X,"CONJUGATE"/4X,"DEPTH
&",6X,"DEPTH"/4X,"(FT)",7X,"(FT)")
DO 15039 I=1,N
DEPTH1=DEPTH(I)
CALL H6123(DISCH,BWID,SSLOPE,DEPTH1,DEPTH2)
15039 PRINT 15040,DEPTH1,DEPTH2
15040 FORMAT(F8.2,F11.2)
PRINT," "
```

```
LQZ=2
CHARACTER ZZZZZZ*2
16000 PRINT, "ENTER RERUN OR STOP"
READ 16001, ZZZZZZ
16001  FORMAT(A2)
IF(ZZZZZZ.EQ.2HRE) GO TO 15000
IF(ZZZZZZ.EQ.2HST) GO TO 20000
PRINT,"ERROR *** RETYPE"
GO TO 16000
20000  STOP;END
SUBROUTINE H6123(DISCH,BWID,SSLOPE,DEPTH1,DEPTH2)
G=32.2;N=2
CALL H6140(DISCH,BWID,SSLOPE,CRIT,CV)
CALL H6124(DISCH,BWID,SSLOPE,DEPTH1,AREA,FORCE)
F1=FORCE
IF(CRIT-DEPTH1) 20060,20070,20080
20060 DEPTHT=CRIT/N;N=2*N;GO TO 20090
20070 DEPTH2=CRIT;RETURN
20080 DEPTHT=CRIT**2/DEPTH1
20090 CALL H6124(DISCH,BWID,SSLOPE,DEPTHT,AREA,FORCE)
F=FORCE-F1
FP=AREA-DISCH**2*(BWID+2.*SSLOPE*DEPTHT)/(G*AREA**2)
DEPTH2=DEPTHT-F/FP
IF(DEPTH2.LE.0.0) GO TO 20060
IF(ABS(DEPTH2-DEPTHT).LE..001) RETURN
DEPTHT=DEPTH2;GO TO 20090
END
SUBROUTINE H6124(DISCH,BWID,SSLOPE,DEPTH,AREA,FORCE)
G=32.2
AREA=DEPTH*(BWID+SSLOPE*DEPTH)
ENERGY=DEPTH+DISCH**2/(2.*G*AREA**2)
FORCE=BWID*DEPTH**2/2.+SSLOPE*DEPTH**3/3.+DISCH**2/(G*AREA)
RETURN
END
SUBROUTINE H6140(DISCH,WIDTH,SSLOPE,DEPTH,CRIVEL)
G=32.2
IF(WIDTH) 30,10,30
30 DEPTH=((DISCH**2)/(G*(WIDTH**2)))**(1./3.)
GO TO 20
10 DEPTH=((2.*DISCH**2)/(G*SSLOPE**2))**(1./5.)
GO TO 100
20 IF(SSLOPE) 25,100,25
25 A=DISCH**2*(WIDTH+2.*SSLOPE*DEPTH)
B=G*DEPTH**3*(WIDTH+SSLOPE*DEPTH)**3
DIFF=B-A
IF(DIFF.LT.0.0001) GO TO 100
DEPTH = DEPTH-0.01
GO TO 25
100 CONTINUE
AREA=(WIDTH+SSLOPE*DEPTH)*DEPTH
CRIVEL = DISCH/AREA
RETURN
END
```

END

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